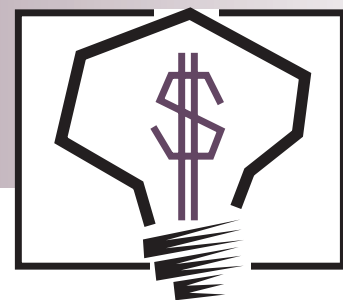


INVENTIONS & INNOVATION

Project Fact Sheet



ENERGY STORAGE FOR PHOTOVOLTAIC SYSTEMS

EFFICIENT AND ENVIRONMENTALLY SOUND ENERGY STORAGE LOWERS ENERGY GENERATION COSTS

Benefits

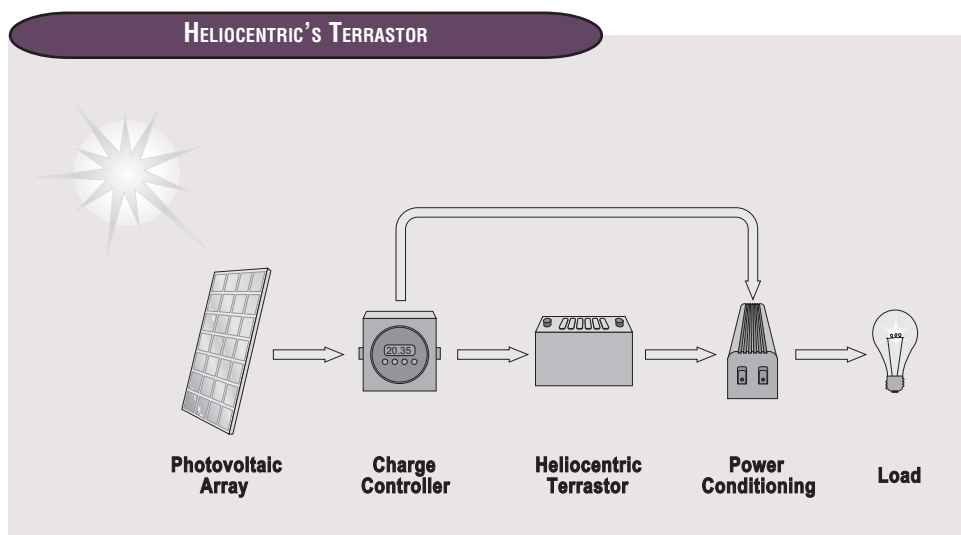
- Reduces photovoltaic system life-cycle cost
- Improves round-trip energy efficiency by 29-34%
- Eliminates maintenance requirements
- Reduces system embodied energy by 6.1 MBTU/kWh_c
- Long life-span —replaces six sets of batteries
- 50% greater available capacity versus competition
- Offers industry-wide savings of 4.9 trillion Btu by 2010

Applications

The technology targets a broad base of photovoltaic consumers including utility, agriculture, commercial, residential, and other sectors. Typical applications include stand-alone and distributed commercial and residential power, commercial UPS, irrigation and pumping, communication systems, and remote power. Other applications include wind energy storage, peak-power shaving, and utility load leveling.

Photovoltaic energy is a rapidly developing industry that has seen substantial growth in the last 10 years. Photovoltaics generate energy from the sun and store it in batteries so it is available even when the sun goes down. The problem has been, up until now, that current battery technologies perform poorly in photovoltaic systems, making these systems energy inefficient, maintenance intensive, and costly to operate. Photovoltaics have the potential to generate abundant clean energy. Yet the energy required to manufacture lead-acid batteries is so high that for many systems the net energy production is near zero. Today, batteries are the weakest link in photovoltaic system technology, and until now there have been no other practical alternatives.

Heliocentric has developed a new energy storage technology, Terrastor, designed to address the problems associated with energy storage in photovoltaic systems. This new type of energy storage achieves energy densities equivalent to lead-acid batteries while dramatically improving upon round-trip energy efficiency, cycle life, available capacity, autonomy, maintenance requirements, environmental life cycle, and embodied energy. These improved characteristics promise to redefine photovoltaic system performance, reduce embodied energy, and lower photovoltaic system life-cycle cost.



Terrastor in a typical photovoltaic system.



Project Description

Goal: Develop and construct commercial-scale system prototypes while improving the materials, processing, and packaging techniques.

Heliocentric has completed foundation laboratory research. In this phase we successfully developed small-scale prototypes, and identified and surmounted the primary technological hurdles. The resulting devices have undergone engineering analysis and economic assessment. Validating the technology, these tests show that under in-system conditions the devices demonstrate significant performance gains over competitive technologies. We have since developed commercial-scale designs and experimentally evaluated elements of this new design while finalizing key patents.

Heliocentric is continuing this research with funding assistance from the U.S. Department of Energy's Inventions and Innovation program. This will help position us for future capital investment necessary for phase-three production engineering, field testing, and commercialization.

Progress and Milestones

The following are the main tasks to be performed:

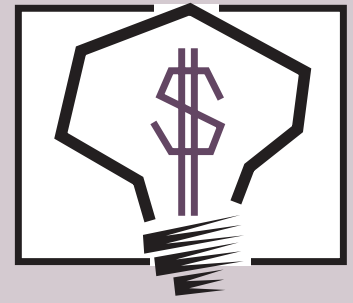
- Prove concept merit and technological potential (complete)
- Develop successful small-scale prototypes (complete)
- Model and analyze performance gains in photovoltaic systems (complete)
- Develop commercial-scale prototypes (current)
- Update and refine market analysis and business plan (current)
- Refine technology and engineer for manufacture (future)
- Field test and partner with photovoltaics and systems suppliers (future)

Economics and Commercial Potential

The photovoltaics industry is an emerging industry that has already grown to over a billion dollars in annual sales and is growing at an average of 25% per year according to DOE EIA statistics. Most photovoltaic systems require energy storage to work. This storage-moderated segment accounts for 65% of the total market share. The US market in 2002 for photovoltaic energy storage is projected to top 1.5 GWh of capacity with an estimated retail market value of \$250 million.

Terrastor's impact on system economics and performance represents a significant step forward in the quality and productivity of photovoltaic energy systems—qualities the market has long demanded but which competitive technologies couldn't provide. Low market barriers to entry and an environmentally clean life-cycle, an important selling point in this market, also position this new technology for rapid market penetration.

The projected annual energy savings is 4.9 trillion BTU by 2010. By 2020 the savings will grow to 34 trillion BTU.



The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and to conduct early development. Ideas that have significant energy-savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

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